IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Wu et al.

Application No.: 10/820,525

Filed: April 7, 2004

Title: METHODS FOR PRODUCING LOW-K CDO FILMS WITH LOW RESIDUAL STRESS

Attorney Docket No.: NOVLP091/NVLS-2889

Examiner: Maldonado, Julio J.

Group: 2823

DECLARATION UNDER 37 CFR § 1.132

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

I, Qingguo Wu declare as follows:

1. I joined Novellus Systems, Inc., assignee of the above-identified patent application, as a scientist in 2002. Prior to joining Novellus, I worked in the Department of Chemical Engineering at the Massachusetts Institute of Technology, USA as a postdoctoral associate for 2 years. I received a Ph.D. from Queen's University, Canada in 2000 and a M.S. from Henan University, China in 1990. I was a visiting scientist and worked in the Department of Chemistry at Cornell University before studying at Queen's University in 1997. I have authored or coauthored more than 50 publications in refereed journals and am an inventor on 6 patents and 10 patent applications. My research efforts include the research and development of low-k dielectrics and low-k barrier materials. I also research film process optimization to address the integration and reliability issues in early development stage.

2. I have extensive experience in depositing and evaluating carbon doped oxide films. At Novellus, I have over the past few years been involved with or directed the deposition of hundreds of carbon doped oxide films. I have evaluated the chemical and mechanical properties of these films according to standard protocols employed in the field.

3. I am an inventor of the subject matter described and claimed in the above-identified patent application. The patent application describes and claims methods of depositing carbon-doped oxide films having low stress and low dielectric constant.

4. Stress related problems are pervasive and critical in Cu-low k integration. Many device failures can be ultimately traced to stresses and their variations at various stages of IC processing. Those failures include interfacial delamination between different materials and cracking within one material during chemical mechanical polishing (CMP) and packaging.

5. We found in our work that both using a C≡C triple bond and silicon containing precursor such as TMSA ($(H_3C)_3Si$-C≡CH) and BTMSA ($(H_3C)_3Si$-C≡C-$Si(CH_3)_3$) etc. and using a dual source electrode with different frequencies to deposit a CDO film are critical in obtaining films with low dielectric constant and low magnitude of stress.

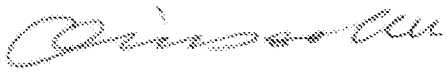
6. I have reviewed and understand the patent to Hyodo et al. (U.S. 7,064,088 B2). The C≡C and Si-containing precursors such as TMSA, BTMSA, PTMS, DTDS and DMSDA, etc., in our application are different from those compounds Hyodo et al. describe in their patent. Hyodo describes precursors of the formula $Si_nO_nR_{2n-m}$, $(Si_nO_nR_{2n-m})X_m$ (n is integer of 3-6) and $Si_\alpha O_{\alpha-1}R_{2\alpha-\beta+2}X_\beta$ (α, β = 1-3), with R and X groups being alkoxy, vinyl, amino and acid radical groups - not C≡C or C≡CH groups.

7. We found in our work that compounds that have carbon-carbon triple bonds and methyl groups, such as TMSA, BTMSA, etc. produce films having lower stress than films deposited with precursors that do not contain carbon-carbon triple bonds. Appendix A shows stress as a function of dielectric constant for different precursors with specific functional groups. In the range of $k < 3.0$, only the precursors (TMSA and BTMSA) having a C≡C group have a stress having a magnitude less than 0 MPa (compressive stress). For TMCTS and DEMS precursors, film stress is much higher than those of TMSA and BTMSA based films although TMCTS and DEMS contain CH_3 group and OC_2H_5 groups, respectively.

8. We also found that alkoxy and vinyl group containing precursors such as DEMS and TVTMCTS, respectively, produce much higher tensile stress compared with C≡C group precursors such as TMSA and BTMSA etc. TVTMCTS is a vinyl group-containing and silicon-containing precursor, TMCTS is a CH_3-containing group and silicon-containing precursor and BTMSA is C≡C group-containing and silicon-containing precursor. As shown in the Appendix B, TMCTS and TVTMCTS based films have stresses are very close to each other for a similar k value although TVTMCTS contains vinyl groups. However, the BTMSA-based film has much lower

stress than TVTMCTS and TMCTS have, which indicates that the C≡C group is very critical in obtaining low tensile stress and low k films.

9. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true. I further declare that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both (under Section 1001 of Title 18 of the United States Code), and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.



Qingguo Wu

7/30/2008
Date